tinctions noted in the present paper, re-examination of these records is indicated.

The writer wishes to thank the institutions that have courteously placed at his disposal their material representing this group: Denver Museum of Natural History (A. M. Bailey); Academy of Natural Sciences of Philadelphia (Rodolphe M. de Schauensee); Museum of Comparative Zoology (J. C. Greenway, Jr.); and United States National Museum (Dr. Herbert Friedmann).

Measurements are based on a series of 10 specimens (unless otherwise specified).

ZOOLOGY.—Postmonorchis donacis, *a new species of monorchid trematode from the Pacific coast, and its life history.*

R. T. Young,[1] University of Montana (emeritus). (Communicated by E. W. Price.)

Hopkins (1941) has described a monorchid trematode in the pigfish (*Orthopristis chrysoptera*) and the spot (*Leiostomus xanthurus*), and Manter (1942) and Hanson (1950) have found the same worm in the grunt (*Haemulon flavolineatum*) although the latter writer questions the identity of the fish which she studied. A trematode of the same genus but a new species has been found by me in several species of surf perches (Embiotocidae), the corvina (*Menticirrhus undulatus*), and spot fin croaker (*Roncador stearnsi*) which I now propose to describe, together with a note on its life history.

The worms were studied mainly in the living condition, but whole mounts fixed in the Dubosq-Brazil modification of Bouin's fluid and in an alcoholic solution of mercuric chloride with a 5-percent addition of acetic acid and stained in acetocarmine and in Ehrlich's hematoxylin have also been employed.

The trematodes were numerous in 1935–36 and again in 1951. No search was made for them in the interim, but the infrequence of their intermediate host, the bean clam (*Donax gouldii*), during this period renders their occurrence then unlikely.

They differ from *P. orthopristis* as follows: Their form is different, being slender rather than rounded and resembling *Genolopa* in this respect. The testis is longer than wide, while the reverse is true in the former, and the posterior notch mentioned by Hopkins is lacking. The vitelline reservoir is inconstant, depending on the state of contraction or expansion of the yolk ducts. The excretory bladder is approximately spherical rather than elongated, while the uterus fills almost the entire posterior body region instead of being restricted mainly to the lateral regions. Black pigment spots are present, either as consolidated "eye" spots or as scattered granules evidently the remains of definite "eye" spots in the larva. The flame cell pattern could not be completely determined. In most specimens the flames were inactive, and in spite of a careful examination several probable cells escaped detection. All that could be seen are shown in Fig. 1. Judged from the close relationship of this worm to *P. orthopristis* it is highly probable if not absolutely certain that the formula is the same as that given by Hopkins for the latter.

Postmonorchis donacis, n. sp.

Slender, elongated worms covered with small spines anteriorly, which gradually disappear near the ventral sucker. Dimensions of fresh specimens, flattened beneath a cover glass: length 0.48 mm; width, 0.207; oral sucker, 0.071; ventral sucker, 0.06; pharynx, 0.048 by 0.031; ovary, 0.037 by 0.031; testis, 0.055 by 0.052; seminal vesicle, 0.105 by 0.095; eggs 0.024 by 0.015. In fixed material the dimensions are as follows: length, 0.336 mm; width 0.07; oral sucker, 0.046; ventral sucker, 0.038; seminal vesicle, 0.059 by 0.0345; ovary, 0.042 by 0.028; testis, 0.047 by 0.033; eggs, 0.021 by 0.012. Pigment spots present. Ventral sucker at about one-third length of body from anterior end. Ceca terminate posterior to anterior end of testis. Vas deferens and metraterm open through a gonopore in the midline just anterior to the ventral sucker. The cirrus sack

---

[1] I am indebted to Dr. Carl L. Hubbs, of the Scripps Institution of Oceanography, for the use of an aquarium in the prosecution of this research, and to the San Diego Zoological Society and the U. S. Bureau of Animal Industry for the occupation of rooms in their laboratories. I also had the privilege of spending a few days at the laboratory of the U. S. Fish and Wildlife Service at Beaufort, N. C. To all these my thanks are due. I am indebted too to Edward W. Johnson, of the University of Maryland, for the preparation of the map.

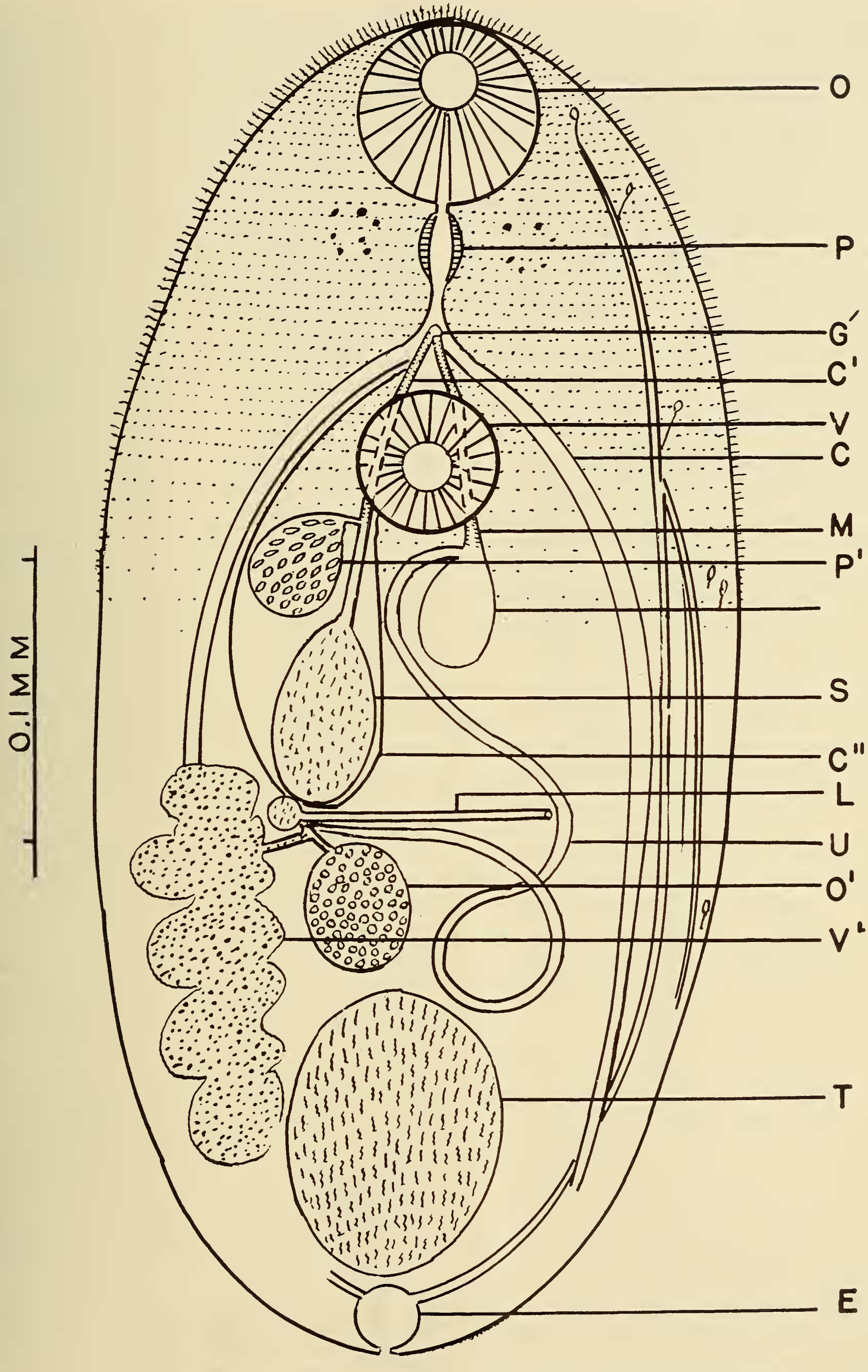

Fig 1.—Free-hand drawing of *Postmonorchis donacis*, n. sp., ventral view.

encloses a heavily spined vas deferens and a distinct prostate gland which joins the latter where it expands into the large seminal vesicle. Metraterm heavily spined anteriorly with a posterior blind sack. Gravid uterus filling almost the entire posterior body and opening into the metraterm at about its mid length. Laurer's canal present. Excretory bladder approximately spherical. Vitellaria dendritic, composed of several lobes on a side, usually extending from the anterior end of the testis to about the middle of the seminal vesicle but occasionally reaching beyond the ventral sucker.

Manter (*l.c.*, p. 350) says of the excretory vesicle in monorchids, "In some genera . . . it is Y-shaped, in others it is I-shaped." No mention of a spherical shape is given. And further, "The seminal vesicle in the Monorchidae is often rudimentary and if present at all is difficult to observe." Regarding the seminal vesicle Manter's statement is at variance with the account and figure (8) given by Hopkins (*l.c.*) for *P. orthopristis* and with my own observations on the present species, while in the latter the excretory bladder differs widely from the accounts of both these authors for the Monorchidae.

Location of the parasite in the gut of the fish.—In the surf perches the worms are found mainly in the rectum though occasionally elsewhere in the gut; in the corvina their distribution is more general. Three possible explanations offer themselves for this distribution in the former: 1, Easier access to oxygen in the rectum; 2, differences in pH between the rectum and other parts of the gut; and 3, chemical differences other than pH between these regions. The first of these is apparently ruled out by the distribution in the corvina. A test of pH in a specimen of *Cymatogaster*, one of the surf perches, made for me at the Scripps Institution showed a difference of one-half to 1 unit of pH between the rectum (5.92) and the rest of the gut from the duodenum to the rectum (6.45–6.90). This difference, however, is not peculiar to the surf perches, tests of the gut of several other species of marine fish made by me showing similar differences.

This leaves the third alternative as the most likely explanation. In a study of the gut of the surf perches (Young and Fox, 1936) the rectum was found to contain a brown or orange-colored pigment derived from the shrimp (*Hippolyte californiensis*), which the fish had been eating at the time. Dr. Fox determined this pigment to be a carotenoid of the xanthophyll series which occurs throughout the gut but is transitory throughout most of the gut, persisting in the rectum for a considerable time, but ultimately disappearing there also when a xanthophyll rich diet is withheld. Apparently the worms find attachment easier in a region which is rich in this pigment than elsewhere. It is not essential however for their attachment and survival as their distribution in the corvina, and occasionally in the surf perches indicates.

In this connection the findings of Nicoll (1913, p. 200) are of much interest. He found *Zoonogenus viridis* "universally in the rectum and in no other part of the intestine . . ." of the sea bream (*Sparus centrodontus*). "The rectal contents . . ., partly from the fact that it feeds largely on Crustacea, are usually of a dull brownish color, but the color of the parasite was much more intensely red."

This similarity in location of two different trematodes in two different species of fish would seem to be more than a mere coincidence.

Larval stages in the clam.—The larvae in the clam occur as sporocysts producing cercariae, which in turn give rise to metaceriae. The size of the sporocysts naturally varies with age, the largest I have seen measuring 0.72 by 0.14 mm in fixed material. The young sporocysts are somewhat motile, changing shape from time to time. When present in large numbers the visceral mass is extensively destroyed, as Martin (1940) found in *Cummingia*, and is yellow in color. The fact that the clam is almost universally infested with metacercariae (see p. 92) in considerable numbers without suffering any apparent harm therefrom renders it likely that either (1) several light infestations succeed one another without serious injury to the host, or (2) the visceral mass is regenerated after partial destruction by the parasite.

The cercaria.—The cercaria is illustrated in Fig. 2. It measures 0.43 mm in length, including the tail, by 0.08 mm in diameter in living specimens. The tail is 0.17 mm long, the oral sucker is 0.045 mm and the ventral sucker 0.039 mm in diameter, the pharynx 0.017 by 0.011 mm. In fixed material the dimensions are as follows: length (including tail) 0.228 mm, diameter 0.042, tail 0.09. There are two eye spots. The anterior half of the body is covered with small spines, while the tail is encircled by numerous rings of overlapping scales which give the appearance of spines.

I could not determine all details of the excretory system. There is a small globular bladder at the base of the tail, with a group of several gland cells anterior to it containing granules which stain in neutral red. From the bladder two excretory ducts extend forward to the region of the oral sucker.

Posterior to the ventral sucker the anlage of the future reproductive organs can be seen.

This cercaria resembles closely *Cercaria myocerca* of Villot (1878) ecxept for a slight difference in the relative length of tail and body. It also resembles *Cercaria cummingiae* of Martin (*l.c.*). Both of these larvae, as well as the present one, infest marine pelecypods, so that in habit as well as structure they appear to be identical. Regarding the latter larva Martin (p. 473) says: "The cercaria has certain characters in common with *Cercaria myocerca*, Villot . . . Both of these larvae have the simple, sac-shaped type of excretory bladder. This seems rather significant since *C. myocerca* is a marine form with a setiferous tail and all other described species of setiferous-tailed marine cercariae have either a Y or U-shaped, or a long tubular excretory bladder. Both species have eye spots. The molluscan host of *C. myocerca* is *Scrobicularia tenuis* which belongs to the same family as *Cummingia*." I regard the present species as identical with *C. cummingiae* which is, to all appearances synonymous with *C. myocerca*.[2]

Regarding the adult worm to which these larvae belong Villot (*l.c.*) considered it to be an amphistome, which, as Dollfus (1925) says, is highly improbable. Martin on the other hand thought it was one of the Allocreadiidae. As will be seen from what follows it is highly probable that the adult worm is a monorchid.

The metacercaria.—The metacercaria can be rather easily excysted by pressure on the cover glass. When removed from the cyst it measures, extended, between 0.3 and 0.4 mm. It is located mainly at the base of the siphons, but occurs also in the gills and the edge of the mantle.

The life history.—It has not been possible to work this out completely. I have shown, as will be seen shortly, that the clam *Donax gouldii* is an intermediate host. But whether this is the only one is uncertain. I have made repeated attempts to infest the clam with eggs from the adult worm but all of them were failures. Many worms containing brown-shelled eggs were teased and put in small vials or beakers with the clams, but no miracidia emerged, nor were sporocysts or cercariae found in the clams so exposed, even when the eggs contained active embryos. Most of these experiments were performed in sea water, but in one, Ringer's solution plus mucous from the gut of an *Embiotoca* was used and in others extracts of the gut of a corvina and an *Embiotoca* were employed. I have also made a few attempts to infest the clams by pipetting eggs between the valves of the shell of four *Donax* but without success.

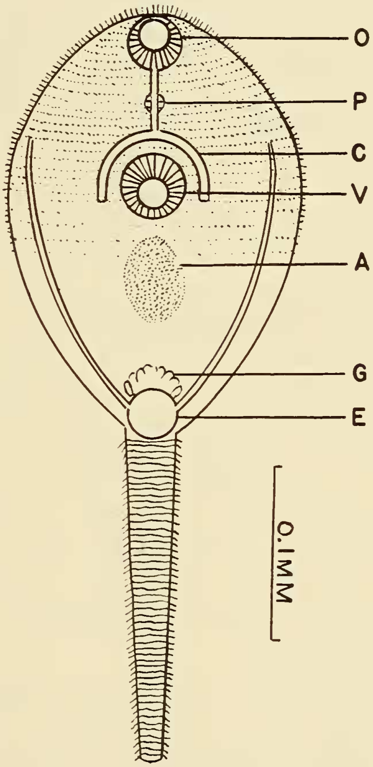

Fig. 2.—Free-hand drawing of the cercaria of *Postmonorchis donacis*, n. sp.

Martin (*l.c.*) has described the life cycle of a related species, *Monorcheides cummingiae*, in the clam, *Cummingia tellinoides* and eels and flounders. He demonstrated the transfer of the parasite from the clam to the fish and postulated its passage in the reverse direction. He also demonstrated the transfer of cercariae from an infested to an uninfested clam, but did not determine

---

[2] Should subsequent experiments prove conclusively that *Cercaria donacis* is identical with *C. myocerca* the specific name *donacis* will be superseded by *myocerca*, which has priority. Until such demonstration, however, I prefer to use the new name, *donacis*.

their mode of entrance into the latter, whether through the mouth or the body surface. I have placed active cercariae in dishes with clams but failed to infest the latter. And the cercariae are not attracted by siphons of the clam nor have I seen any of them ingested.

I have, however, found a few cercariae in the clam which lacked tails and were surrounded by a very thin cyst, evidently the first stage of the metacercaria. I have also observed a second stage, intermediate in size between the first and the final stage, which latter is identical with the young worm.

It seems certain that eggs teased out of the worms are not infective. It may be that they require a period of ripening in sea water before becoming so. Martin (*l.c.*), however, found that exposing eggs of *Monorcheides* to sea water for three weeks failed to induce development so that this hypothesis is improbable. It is also possible that a third host is involved in the cycle, perhaps a small copepod which may be ingested by the clam.

The reverse transfer, from clam to fish has succeeded in many experiments, as the following data will show.

A gravid *Embiotoca jacksoni* spawned in an aquarium at the Scripps Institution several days after its capture. The young fish were divided into two lots of seven each, one lot being fed abundantly on *Donax* while the other lot served as controls. One of the experimental fish was found on examination to contain *Postmonorchis* while the controls were all negative. Another of the experimental fish was also infested with small trematodes but the condition of the worms when examined rendered positive identification impossible. It is highly probable that they too were *Postmonorchis*.

Of seven other *Embiotoca* fed *Donax* six proved positive for the parasite, while of 17 controls 14 were negative and three positive. Of 13 *Micrometris* fed *Donax*, 12 proved positive and one negative, while of 44 controls 43 were negative and one positive. In Mission Bay, an arm of the sea near San Diego, *Cymatogaster* breeds abundantly in April and May in the kelp and eel grass which line its shores. There are no *Donax* in the bay and the young perch are apparently never infested. Feeding *Donax* to 24 of these young fishes resulted in infesting 16, while 16 control fish were all negative. That all the experimental fish in these experiments received metacercariae is rendered virtually certain by the fact that of 400 clams examined only five lacked these organisms.

Fig. 3.—Map of the San Diego region, Calif.

I have calculated the significance of these results by a formula in Tippett (1937)

$$T = \frac{X - X'}{S\sqrt{1/N + 1/N'}} \text{ and } S^2 = \frac{\Sigma(x - X)^2 + \Sigma(x' - X')^2}{N - 1 + N' - 1}$$

where X and X' represent the averages of the experimental and the control observations, x and x' the value of each experimental and control observation respectively, and N and N' the number of these observations. Knowing the value of T and the number of observations, both experimental and control, the probability of the result, based solely on chance, can be determined from a table compiled by Dr. George F. McEwen of the Scripps Institution of Oceanography.[3] Applying this formula to the first of the above experiments it becomes $T = (.143 - 0)/S\sqrt{.2857} = 1.1$, where $S = \sqrt{(1 - .143)/12} = .25$, which gives a probability of .1465. That is, there is about one chance in seven that this result might be due to chance alone. Including both of the infested experimental fish in the calculation, which is reasonably justified, the probability becomes 0.044, or about 1 in 25. Making a similar calcula-

---

[3] This table is based on one in Fisher's *Statistical methods for research workers* but is more comprehensive.

tion for the other experiments recorded above the probabilities in none of them exceed 1 in 1,000.

The percentage of infested fish from different regions is also significant. *Donax* occurs only on the beaches where it is subjected to wave action and is alternately submerged and exposed by the tides. In both Mission and San Diego Bays (see map) tidal action occurs but wave action is absent, as is *Donax*, while on the beach at La Jolla it is present in vast numbers in certain years. Both of the bays connect with the sea through narrow channels which may serve to isolate their fish from the open sea, at least for considerable periods. Unfortunately I have inadequate data for the same species of fish, but a comparison of different species, all of which serve as hosts for the parasite is of much interest. In 1935 of 26 *Embiotoca* taken at La Jolla all but three were infested, several of them heavily, while of 33 *Micrometris* and 64 *Cymatogaster* from San Diego Bay only one of the former and none of the latter were infested. Many corvina were also taken at La Jolla in this year all but one of which were infested. It is obvious from these results that fish which have access to *Donax* are extensively infested, while those deprived of it seldom are.

BIBLIOGRAPHY

Dollfus, R. Ph. *Liste critique des cercaires marines à queue sétigère signalées jusqu'à present.* Trav. Stat. Zool. Wimereux **9**: 43–65. 1925.

Hanson, M. L. *Some digenetic trematodes of marine fishes of Bermuda.* Proc. Helminth. Soc. Washington **17**: 74–88. 1950.

Hopkins, S. H. *New genera and species of the family Monorchidae (Trematod)a with a discussion of the excretory system.* Journ. Parasit. **27**: 395–407. 1941.

Manter, H. W. *Monorchidae (Trematoda) from fishes of Tortugas, Florida.* Trans. Amer. Micr. Soc. **61**: 349–60. 1942.

Martin, W. E. *The life cycle of* Monorcheides cummingiae, *with special reference to its effect on the invertebrate host.* Biol. Bull. **79**: 131–44. 1940.

Nicoll, W. *On two new trematode parasites from British food-fishes.* Parasitology **5**: 197–202. 1913.

Tippett, L. H. C. *The methods of statistics.* London, 1937.

Villot, F.-C.-A. *Organization et développement de quelques espèces de trématodes endoparasites marins.* Ann. Sci. Nat. Zool., 6e ser., **8**: 40 pp. 1878.

Young, R. T., and Fox, D. L. *The structure and function of the gut in surf perches (Embiotocidae) with reference to their carotenoid metabolism.* Biol. Bull. **71**: 217–37. 1936.

ABBREVIATIONS USED ON FIGURES

A, reproductive anlage.
C, caecum.
C′, cirrus.
C″, cirrus pouch.
E, excretory bladder.
G, glands.
G′, gonopore.
L, Laurer's canal.
M, metraterm.
O, oral sucker.
O′, ovary.
P, pharynx.
P′, prostate.
S, seminal vesicle.
T, testis.
U, uterus.
V, ventral sucker.
V′, vitellarium.

PROCEEDINGS OF THE ACADEMY

458TH MEETING OF BOARD OF MANAGERS

The 458th meeting of the Board of Managers, held in the library of the Cosmos Club on November 17, 1952, was called to order by President Ramberg at 8:03 p.m. with the following in attendance: Walter Ramberg, H. S. Rappleye, J. A. Stevenson, W. F. Foshag, A. T. McPherson, W. R. Wedel, Sara E. Branham, W. W. Diehl, F. M. Defandorf, Frank M. Setzler, A. G. McNish, L. A. Spindler, Herbert G. Dorsey, Martin A. Mason, E. H. Walker, W. N. Fenton, J. R. Swallen, and J. P. E. Morrison.

The President announced the appointments of W. T. Read and N. L. Drake to the Science Education Committee.

It was recommended that the Committee on Policy and Planning together with the Executive Committee consider publishing a simplified Red Book, and that it list the Members of the Academy, the Constitution and the Bylaws, and information pertaining to the objectives of the Academy, and that a page be devoted to each of the Affiliated Societies. The hope was expressed that this material can be published early next year.

Chairman McPherson, of the Committee for the Encouragement of Science Talent, presented